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ABSTRACT

Computers and robots are becoming increasingly more advanced, with smaller and cheaper computers now doing jobs once reserved for huge multimillion dollar computers and with robots performing feats such as painting cars and using television cameras to simulate vision as they perform factory tasks. Technicians expect computers to become even more powerful in the near future, for "intelligent" robots to be developed that will use vision and tactile sensors to adjust to the environment (e.g., change direction or move the arm slightly to the left before picking up a part). Such technological advances raise ethical issues: how to provide for the thousands or millions of workers who may be displaced from their jobs; what persons should do with the leisure time that may be created by the increased use of this technology; and at what point robots' intelligence and possible superiority over people should be acknowledged. One area in which computers and robots will have a particular effect is that of education, especially adult education. The use of these tools will affect the time, the place, and the process of adult education. For example, advancing technology will force workers to retrain, pushing forward the concept of lifelong learning. At the same time, increased portability of computers will allow one to learn in a variety of places, especially the home, by accessing data banks all over the world. And finally, the use of computers will change the emphasis of learning from acquiring facts to learning how to think. To meet these changes in adult education, adult educators will have to be aware of the impact that computers are having on our society and provide the resources and leadership necessary to help adults learn to adjust to these changes and face life's challenges. Adult educators should be prepared for the changes and not just react to this transition. (KC)

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THE INTERDEPENDENCE OF COMPUTERS, ROBOTS AND PEOPLE

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COMPUTERS

We are approaching the fifth generation. Approximately 25 years ago, the first electronic computer was delivered to the census bureau to assist in compiling the massive amounts of data required for census reporting. (Levine, 1982) The latest supercomputers, the Cray-1 and the CYBER 205, are considered the fourth generation. "If the aircraft industry had evolved as spectacularly as the computer in the last 25 years, a Boeing 767 would cost $500 today, and it would circle the globe in 20 minutes on five gallons of fuel." (Toong, & Gupta, 1982)

Types of computers. Today, there are three major types of computers in common use: the mainframe, the minicomputer, and the microcomputer or personal computer. Use of the mainframe computer has been limited to large organizations, universities, business, or industries, because of the large costs for maintaining it. Although they are smaller and less expensive now, they still require special rooms with a controlled environment and technical personnel to do the actual operations required.

Access to these large computers is through terminal, a keyboard with either a CRT (cathode ray tube, more commonly known as a television screen), teletype display, or through the card reader. To use the card reader, a technique known as batch, the user must type at least one card for each line of a program. Complex programs can involve thousands of cards and one typographical error on one card, or one card in the stack upside down or backwards can cause the entire program to fail. The turnaround time for "batch"--that is the time between submitting a deck of cards and getting back the printout from the computer--can be as little as half an hour or as long as several days, depending on the system.

Frustration is eased greatly by using the terminal on what is known as a timesharing basis. This means that the computer systematically cycles through all the terminals and responds to each command in a certain specific order. While using terminals, it is possible to type the next instruction and wait as long as a few minutes for the computer to respond. Usually the computer gets to any user's message in a few seconds. If a hardcopy, or printout, of the work is needed, the user must command the computer to send the information to the printer. In a few cases, users have direct access to the printer and can obtain the hardcopy as soon as the computer prints it. In most cases, the printer is isolated from the users and the user must wait for the technical personnel to remove the copy from the printer and return it to the user. Working with mainframes can be frustrating and time consuming operation.

The second type of computer in wide use today is the minicomputer. Minicomputers are primarily used in scientific, laboratory, or industrial settings to control experiments or operate equipment. The method of communicating with the minicomputer is usually primitive, involving instructions in machine language (hexadecimal commands) of assembly language (crude word commands). The instructions are usually encoded as a series of punched holes on a paper tape. These minicomputers are difficult for an untrained person to use. The advantage of minicomputers is that they are small--usually two feet square and six feet tall, reasonably portable, and reasonably inexpensive.

The third type of computer in wide use today is the microcomputer or personal computer. Some people differentiate between microcomputers and personal computers. They contend that microcomputers are single use

machines, while personal computers are multipurpose. The local video-game machine would then be considered a microcomputer since it is permanently programmed to play kill the aliens, while a personal computer can be reprogrammed for a wide variety of uses. Personal computers remove many of the difficulties of working with mainframes and minicomputers. They are individualized, compact, and portable. The speed of process is much slower in comparison to mainframes, but the user does not have to share or take turns. The user does not have to go to a special location, personal computers are perfectly safe when operated in the typical home environment. Most personal computers have the capability of operating with any of the languages available on a mainframe computer.

The main limitation on the personal computer is small memory--how much information can be stored in the machine at any one time. However, permanent memory capabilities are expected shortly to increase from 64K to 256K in the next year or so. Computer storage is accomplished by assigning a 0 or a 1 to a given location or bit of memory. A series of 8 bits is called a byte. A byte can represent one alphabetic character or one or two decimal numbers. A kilobyte is 2 raised to the 10th power or 1,024 bytes. Kilobyte is abbreviated K, so a 64K machine can store 64 times 1,024 or 65,536 characters or about 10,000 words of English text. A 256K machine can store approximately 256,000 characters or about 40,000 English words.

There are other methods of storing information besides the permanent storage. Cassette storage and floppy disks are the most widely used methods available for personal computers. Cassettes and

floppy disks work on the same principle, the 0 or 1 is encoded on the tape or disk by the orientation of the applied magnetic field. The information can then be read by a magnetic head and fed back into the computer. Cassettes are slow because the cassette must be played at a speed at which head can accurately read the information. Floppy disks are much faster and easier to use; however, the disk drives cost much more. Another way to extend the memory of a personal computer is to use a modem (modulator-demodulator) and the telephone to establish contact with a mainframe computer. Most personal computers have the capability of attaching a modem, so for the cost of a phone call, the user can have access to the larger computer on a timesharing basis.

A typical personal computer system consists of the computer, a moniter or CRT, a disk drive and a printer. Some systems are sold as packages and others are sold piece by piece. If the price quoted is less than $500, then it is safe to assume that the offer is good for the computer itself. The average cost of a personal computer system is expected to fall from about $2000 now to $1000 by 1985 and $750 or less by 1990. (Toong, & Gupta, 1982)

Another type of computer that is marketed today but is not in wide use is the supercomputer. As of January, 1982, there were only about three dozen of these machines in the world. (Levine, 1982) These machines operate with 64 bit words, compared to the 8 bit words of most personal computers, and have over 4 million of these 64 bit words of fast memory, compared to 256 thousand of the 8 bit words in an advanced personal computer. Fast memory is the central memory which can perform operations at the rate of 100 million operations per second. These

supercomputers cost between $10 and $15 million. The primary uses of these machines lie in the fields of aerodynamics, seismology, meteorology, and atomic, nuclear, and plasma physics. (Levine, 1982) Supercomputers are in their infant stage. At this point, there are only two types of problems that warrent the expense of the supercomputer: those that must make a few calculations on vast amounts of data or those that must make vast amounts of calculations on a few sets of data.

All of the computers discussed so far are "number crunchers", that is, they all rely on mathematical rules for manipulating numbers. Even word processing on these machines is reduced to a mathematical problem. It is not possible to reduce every problem to mathematical symbols. However, up to now, every computerized problem has been solved by considering the consequences of all possible choices, a tedious exercise for humans, but a simple process for the speedy computer. As the complexity of the problem tackled increases, the possible choices increase beyond the realm of even the fastest computers.

DEVELOPMENT OF "THINKING" COMPUTERS

Ever since computers were first introduced, people have speculated on what it means to be intelligent. In the early years of development, there was nothing about the technology which implied that "artificial intelligence" was a possibility. Even so, scientists have been fascinated by the notion of machine intelligence. The first efforts were to generate programs which could play chess, since chess has been considered the game of intellectuals. The game also has a finite set of clearly defined rules. The difficulty in developing a chess-playing computer resided in the complexity of considering the consequences of every possible next move in chess requires tremendous amounts of memory.

It was only after the notion of heuristic programming surfaced that world class chess programs were born. There are two aspects of heuristic programming that make it different from regular programming. First, the program is set up to establish a data base. So, when the chess program encounters a move it has never "seen" before, that move is stored into its data base. In this manner a "knowledge base" is built up over time and the computer in effect learns from the play. The second aspect of heuristic programming is that the program does not consider every possible choice. Methods of generating hypotheses about the game are included in the programming so the computer only deals with the most likely choices.

The most successful artificial intelligence projects are based on this notion of heuristic programming. Artificial intelligence systems in use are called "expert systems". Examples of expert systems are diagnostic programs for families of diseases, search programs for finding oil, and a theraputic counseling program. The diagnostic programs have a success rate equal to that of an expert in the field. Such a result is not surprising since the computer does not forget any of the questions or the appropriate responses. Many people prefer giving the information to the computer. (Feigenbaum, & McCorduck, 1983) In counseling sessions, the computer can keep track of the responses of the last 2,000 patients and make fine distinctions based on these comparisons. A human counselor could not possibly keep that much information close at hand. (Van, 1983) Herbert Simon, the noted economist, contends that most humans can only keep four or five aspects of a problem in mind at one time. (Tierney, 1983) Insufficient memory and speed continue to plague major advances in artificial intelligence.

FIFTH GENERATION COMPUTERS

Yet, some promising breakthroughs are probable. The Japanese announced in October, 1981, that they were preparing to embark on an intensive government-sponsored research program aimed at designing and building the next generation of computers to handle artificial intelligence applications with ease. Many companies are engaged in this research project with a ten-year budget of $800 million at their disposal.

In this country the initial reaction to Japanese plans was disbelief, followed closely by hysteria. Major concern focused on Japan's potential domination of the computer market and position in world trade.

Few analysts question whether the Japanese will succeed ultimately. The debate centers on whether the U.S. should launch a comparable government-sponsored effort. (Feigenbaum, & McCorduck, 1983) To date, such a project has not been established. However, U.S. corporations have collaborated on similar large-scale research projects. The Microelectronics and Computer Technology Corporation, headed by Admiral Bobby Inman and backed by 12 American corporations (including Control Data, Honeywell, RCA, and Motorola) has invested an annual budget of $75 million in research on the development of the fifth generation computer. The Semiconductor Research Corporation has the backing of Control Data, IBM, Hewlett-Packard, Digital Equipment Corporation, and Motorola and will sponsor $30 million in research at American universities next year." (Lemmons, 1983) The Defense Advanced Research Projects Agency (DARPA) is rumored to be ready to spend $1 billion on research into

artificial intelligence. In all the U.S. government and key businesses are investing heavily in artificial intelligence.

There are deep implications in pursuing the path toward artificial intelligence. Christopher Evans (1980) suggested that the result would be a world of computer slaves to look after every human need. An overriding implication for holding intelligent entities as slaves is: "Who will serve whom?"

ROBOTS

In 1922, Karel Capek's play Rossum's Universal Robots, (RUR) shook the world. The play dealt with malevolent robots that took over the world. In the play the term "robot," a Czech word for menial labor, was coined. By the late 1950's and early 60's, attitudes toward robots had changed. The citizenry seemed more concerned about the potential invasion of earth by grotesquely-shaped aliens, whereas robots were portrayed as more benelovent. Isaac Asimov, in his book Robots, introduced the notion that robots could be built to obey certain rules which would forever prevent them from harming human beings.

In 1961, robots became a reality. Unimation, then a subsidary of Condor Corporation, manufactured the first robot, which was sold to General Motors. That year, three units were sold worldwide. By 1970, 600 robot units were sold in North America. (Tanner, 1982) As of 1981, the robot population of the United States had grown to 4300 units. Today, there are 6200 units installed in the United States alone, with more than 32,000 units worldwide. Robotics International, a division of the Society of Manufacturing Engineers, projects that 100,000 robots will be installed in the United States by 1990. (Lohr, J, 1983)

What is a robot? What are current robot capabilities? What potential advances will occur in the near future, say within the next seven years? What technical barriers exist that render certain applications futuristic? What is the current and projected impact of robots and automation on employment? How are the unions reacting to the implementation of automation and robotics? And what are the implications of this latest technological development for adult educators?

To be a "robot." In an attempt to answer these questions, it is important to understand what is meant by the term robot. A 20th century robot is NOT a metal humanoid reminiscent of R2D2 or C3PO. Robots are made up of a highly flexible, many jointed arm connected to a microprocessor which serves as the brain. Sometimes robots come equipped with a television camera to simulate vision. According to the Robot Institute of America, an industrial robot is "a reprogrammable multi-functional manipulator designed to move material, parts, tools or specialized devices through variable programmed motion for the performance of a variety of tasks." (Tanner, 1982) Jack Lohr (1983), a board member of Robotics International, in a presentation at Ball State University on November 3, 1983, suggested that today the main distinctions that need clarification are automation and robots. Automation refers to a microprocessor run system which is "dedicated". That is, it performs a single particular function and that is all. If a different job needs to be done, a new dedicated system would need to be installed. Current industrial robots are programmable to perform a variety of closely related tasks. For example, a spot welding robot can be reprogrammed to perform a variety of welds on a variety of materials from a wide choice of orientations. Still, a spot welding robot cannot

load or unload a piece, drill a hole, or cast a die. A different specialized robot is needed for each task. In this sense, it is clear that the development of a generalized, multi-purpose industrial robot is still over the development horizon.

Robot uses. Many highly specialized robots are available on the market today. Most industrial robots are used in the automotive industry. (Lohr, J, 1983) To get an indication of how quickly things change, compare the breakdown of current robot applications given by Tanner (September, 1982) in Table 1, with the breakdown given by Lohr (November, 1983) in Table 2.

TABLE 1

TYPE OF ROBOT	PERCENTAGE
1. Materials Handling	25.0%
2. Loading/Unloading Stamping Presses Injection Molding Machines	23.0%
3. Casting and Forging	21.0%
4. Spot and Resistence Welding	18.0%
5. Arc Welding	4.0%
6. Spray Painting	4.5%
7. Assembly	less than 1.0%
8. Grinding/Polishing	0.5%
9. Research and Development	2.0%

TABLE 2

	TYPE OF ROBOT	Numbers	Percentage
1.	Spot Welding	2500-3400	40-50%
2.	Die Casting	600	9.7%
3.	Machine Loading	over 200	over 3.2%
4.	Foundry	approx 200	approx 3.2%
5.	Plastic Injection	approx 100	approx 1.6%
6.	Press Loading	few	---
7.	Spray Painting	few	---
8.	Body Inspection	few	---
9.	Palletizing	few	---

Tanner (1982) indicated that the big growth areas should be in loading/unloading and arc welding, both of which depend on breakthroughs in robot vision capabilities, as well as assembly which depends on breakthrough in both vision and tactile research. Thorton reported in American Metal Market (1982) that demand for spot and resistance welding has peaked and the greatest demand will be for materials handling. Iohr (1983) stated that the big growth area will be assembly. The point is that no one seems able to predict what the next "hot selling" area will be.

Lack of adaptability in the current robot population has lead the robot research and development teams to focus on the "intelligent" robot. Intelligent robots use vision and tactile capabilities to adapt to the environment. (Murakami, 1982) In a sense, these intelligent robots can be considered self programming since input from the vision or

tactile sensors cause the robot system to adjust itself: change direction, reduct voltage on a weld, or move the arm slightly to the left before picking up a part. Any or all of these actions take place without external input from an operator or programmer.

More advanced robot systems are in the developmental stages and are expected to be operating by 1990. Most of these systems are dependent on improved vision systems. Packaging and food inspection robots can determine if the labels have been properly printed, if the labels are clean, and if the labels are oriented properly. Systems of this type are currently being installed in a few trial locations. In bin-picking, a vastly more difficult application requiring both vision and tactile breakthroughs and still in developmental stages, robots can "look" into a bin of assorted and randomly oriented parts, pick out the correct part and position the part for assembly or installation. ("Robots have," 1983)

Robot welding in all phases of the manufacturing process hinges on the ability of the robot, by inspecting the environment of the weld, to adjust orientation of the welder, voltage to the welder, and duration of the weld required for a variety of parts and situations. The welder robot can look at the next situation and determine exactly what adjustments need to occur without the input of an operator. For assembly to be cost effective, the robot needs to have pick and place capabilities as well as the ability to decide the correct order of the parts required for assembly and the ability to make minor adjustments in orientation of parts, again, without the input of an operator. ("Robots have," 1983)

Prototype sheep-shearing stations have been installed in Australia. ("Robots have," 1983) According to Joseph Engelberger, president and founder of Unimation Inc., in an interview conducted by Peter Gwynne (1983), "one simply clips an electric power supply to the sheep's nose and behind, and when the voltage is turned up, the sheep becomes rigid. Two robots, one on each side of the sheep, then proceed to do shearing job, using a [computer] program, that generally recognizes the size of the sheep involved."

In the near future, a computer controlled drill attached to a CAT scan will assist brain surgeons with the difficult task of determining the exact location for entering the cranium, as well as drilling the hole. This automation will reduce operating time by five or six hours. (Gwynne, 1983)

At present, robots lack mobility. Ideally, a robot can enter a room, scan the environment, determine a clear path, and procede to cross the room. At present, robots can move along tracks (Lohr, 1983), but independent motion is limited by poor vision and the inability of existing software (computer programs) to determine the center of an opening (door) so the robot can aim for the middle and decide if it will fit through the opening. (Resnick, 1983)

The limitations in better applying and utilizing existing vision technology lie in three areas. First, there is no industry wide standard for component development, which could allow vision systems to be build in modular fashion and then to be coupled with any possible robot system. Currently, each vision system must be custom built for each new application. The second problem is that no standard language

exists for vision interfacing. This means that with each installation, a vision software engineer must go to the factory and write the necessary software so the vision system can communicate with the robot system microprocessor. The third problem is the lack of sufficient programmers knowledgeable in vision software to perform the job of modifying the vision programs for the specific task. (Kinnucan, April 1983)

Ideally, robots can be controlled by the spoken word, rather than typewriter-like keyboards, or machine language keypads. The difficulties with speech lie not in reproducing speech-like sounds, but in understanding the spoken or even written word. It is relatively simple to repeat pre-programmed words, but even reading aloud from written text either requires an large lexicon of rules or an appreciation of context. Devices exist which can read books for the blind or broadcast the news and weather (McDermott, 1983); however, even with complex sets of rules, the systems make mistakes in sounding the words. To sound conversational, the spoken passages need prosody, those countless changes in pitch, intensity, and timing that overlay the words. (McDermott, 1983)

The next step is speech recognition.

> "Devices capable of recognition of isolated words or short phrases from a vocabulary of between 10 and 30 words are commercially available and are economically practical in some applications. In research laboratories there are speech recognizers with vocabularies of up to 1,000 words, systems that recognize limited-vocabulary sentences with brief pauses between the words and systems that recognize small, the syntax is limited, and the speaker is careful. ... [The] mere elaboration and extrapolation of current technology will not lead to the development of machines that match the human capacity for speech recognition." (Levinson & Liberman, 1983)

The difficulties in speech recognition lie primarily in understanding context. With the development of artificial intelligence systems, the computer will be able to determine the context of the spoken statements. The development of artificially intelligent speech recognition systems for common use will occur after 1990. (Feigenbaum & McCorduck, 1982)

ISSUES OF ROBOTICS R & D

What research is underway to bring about these needed breakthroughs? There are approximately a dozen research centers across the country. At Case Western Reserve in Cleveland, for example, the Intelligent Systems Center has been established with the support of unnamed Cleveland industries. The goal of the Intelligent Systems Center is to pull interdisciplinary research toward the single goal of developing intelligent robots. One of these intelligent robots will "solve problems, explain its actions in natural spoken or written language, learn and think of concepts, and form hypotheses." (Kropko, 1983) Further, Paul J. Drongowski, assistant professor of computer engineering and active in the development of the Intelligent Systems Center envisions a robot workforce in which some machines bring the material to other machines which do the machining, then other machines would transport the parts to still other machines for assembly, then still other machines would move the part to inspection, where other machines would do the testing. (Kropko, 1983)

This may seem futuristic, however, there are factories in operation today using what is known as flexible manufacturing systems (FMS), primarily in the machine and tool industry. Flexible manufacturing systems are limited production runs of disparate parts. "A flexible

manufacturing system can consist of several machine tools fed by automatic materials handling equipment, and robots, all under the direction of a host computer." ("Flexible manufacturing awaits," 1983) It seems that the future is now. While Japan does have the edge in implementing this technique, they are also introducing the United States to this technique. Mazak Corporation, a Japanese firm, opened a machining plant in Florence, Kentucky, a suburb of Cincinnati, which makes 180 distinct parts. Under batch operations the pre-FMS method, the plant would need about 240 workers to operate. The Mazak plant runs three shifts with 15 workers on the day shift, four workers on the evening shift, and no workers on the third shift. There is a single night watchman for the nightshift. (Kinnucan, July 1983)

Technology exists for the widespread implementation of FMS. However, barriers to implementation have slowed adoption in the United States. Manufacturers site the high costs involved in implementing, the difficulties resulting from needed organizational change, and potential problems of installing relatively new techniques. While the Japanese see FMS as a way to gain on US dominated markets, fewer than five percent of all machine tools installed in the United States are numerically controlled (Kinnucan, July 1983) and only ten percent are shipped with robots attached (Lohr, J, 1983).

Automation. Should companies move towards total automation? M. Eugene Merchant (1983), of Cincinnati Milacron, Inc., a major manufacturer of robots and FMS systems, sites three types of benefits for installing FMS: social factors, economic factors, and non-quantifiable benefits. Social factors include the facts that (1)

workers are increasingly shunning jobs in manufacturing, and (2) workers and the government are trying to improve working conditions. Economic factors are (1) FMS speeds up the work process, and (2) the company can get more work from costly equipment. The unquantifiable factors are (1) increased quality, which brings with it (2) lower quality assurance costs, (3) improved adherence to schedules, (4) decreased paper flow, and (5) improved working conditions in the form of decreased risk of accident, relief from heavy physical labor, and relief from monotonous work.

Why then are the unions not concerned with robots and FMS? The main reason is the slow economy. The second reason is that few workers have actually been replaced by FMS today. The third reason is that union officials believe that without the introduction of some robots and FMS, the United States will loose its competitive edge worldwide and jobs will be lost anyway. (Guterl, 1983)

Job loss. How many jobs will be eliminated? Timothy L. Hunt (1983), a senior Research Economist for the W. E. Upjohn Institute for Employment Research at Kalamazoo, Michigan, sites very conservative figures. His figures are based on today's technology and capabilities remaining unchanged until 1990. Hunt projects that 100,000 - 200,000 jobs will be eliminated. This represents only one percent of the total workforce. Occupations that will feel the impact most dramatically will be auto painting (30-40% of all jobs lost) and welding 15-20% of all jobs lost. With a turnover rate of three percent per year, absorbing a loss of one percent in ten years does not seem like such a difficult task. Hunt projects further that 32,000 - 64,000 jobs will be created. The bulk of the job demand will be in the fields of engineering. The

main problem that Hunt sees is that the jobs lost will be for the youth and unskilled, while jobs gained will require high skills. He concluded that "more jobs will be created by ending the recession than were created by high technology in 10 years."

Japan is much further engaged in automation than the United States. Japan's Nissan Motor Company was reported to have signed an agreement with its union guaranteeing that workers will not be dismissed or demoted because of automation and the introduction of robots. (Lohr, S, March 1983)

The latest reports (Keefe, October 1983), indicate that the workers are moving from "psychological" contracts for lifetime employment to legal contracts guaranteeing that jobs will not be lost to automation. An important factor in interpreting the Japanese lay-off statistics is that Japan only counts full-time employees. Women are considered part-time, even if they work a 40 hour week. The Japanese do not have lay-offs, they merely cut back on part-time help. (Guterl, 1983) A report completed by a student of a labor relations at Tokyo University indicates that older workers feel a great deal of resentment. This resentment is attributed to: repeated transfers, young "technical elite", lack of advancement, and discrimination due to obsolete skills. (Guterl, 1983)

U.S. labor unions seem more concerned with the recession than with the implications of further robotization. The only voice raised to date is the Internation Association of Machinists and Aerospace Workers (IAMAW). In November, 1982, representatives of IAMAW ratified a 10-item "Technological Bill of Rights". Among the provisions are profit

sharing, a shorter workweek rather than loss of income, the concept of taxing the machinery the same as a worker, and worker monitoring so that higher speeds on production lines can be negotiated. ("Bill of Rights'," 1983)

What are the implications of increased implementation of robots and FMS? A rift may develop between "technically-capable" and "technically-incapable" workers. Many people were laid off as a result of the recession. During the recession, many companies installed equipment, either robots or the start of FMS systems. Once the recession has passed, many workers will not be recalled. While robots and FMS have not been the direct cause of lay-offs in many cases, many jobs have been eliminated. Therefore, Guterl (1983) predicts that substantial resistance to automation will not be felt until white collar jobs are threatened.

What will happen in a society in which self-worth is measured by the kind of job held? What will happen when white collar jobs are also eliminated by the introduction of improved expert systems in an expanding range of fields? What will become of humankind in a leisure society? Will society become a welfare state? If machines are the only workers, who will own the wealth? Will the machines dole out our allowances? What will be the role of the adult educator? For that matter, what will be the role of education?

INTERDEPENDENCE

> "The reasoning animal has, perhaps inevitably, fashioned the reasoning machine. With all the risks apparent in such an audacious, some say reckless, embarkation onto sacred ground, we have gone ahead anyway, holding tenaciously to what the wise in every culture at every time have taught: the shadows, however dark and menacing, must not deter us from reaching the light."
>
> Edward A. Feigenbaum & Pamela McCorduck (1983)

Computers have and will continue to have an enormous impact. The invention of the computer has been compared to the inventions of language, writing, the printing press, and the steam engine. Many writers suggest that changes that computers and their cousins, robots, will have on society cannot be comprehended as yet.

Computers exert a tremendous force that is altering the world in which we live. There are choices that lie before mankind that must either be faced decisively or it will simply become a pawn of chance. We need to beware of falling prey to a fatalistic philosophy about technological advances. Weizenbaum (1976) warns: "The myth of technological and political and social inevitability is a powerful tranquilizer of the conscience. Its service is to remove responsibility from the shoulders of everyone who truly believes in it." Education should equip an individual with the skills necessary to shape one's environment and not be controlled by external forces. Adult educators can play a significant role in educating people in how to control and use computers and robots wisely, as we move into the future.

DEVELOPMENTS IN COMPUTER AND ROBOTIC TECHNOLOGY

To fully understand what may happen in the next 15 years, we must begin by examining what is likely to occur in the development of computers and robots.

More Power For Less Money. Integrated circuits, used to build computers, will become more powerful. This means that the chips will be capable of storing more data and processing at faster speeds than is now possible. A more significant aspect of this power is the subsequent reduction in cost. A contemporary example of this can be seen in the

IBM Personal Computer. For less than $2,500 it is possible to buy the IBM PC, which has a central processing system more powerful than an IBM 360-40 mainframe computer that dominated the commercial computer world from 1964 to the early 1970's and cost $497,000 (DeVoney & Summe, 1982). It is possible that by 1998 we will have a desktop computer, that costs less than $10,000, and is capable of performing 400 million instructions per second, like the present Cray supercomputer.

Increased Storage Capacity. Memory storage will rapidly increase while the cost decreases. A leading storage manufacturer, Shugart, has announced the availability of a videodisc based storage unit for only $6,000, that can store 1 Gigibyte (1 billion bytes) of data on a single disc. This translates into approximately 25,000 pages of information. Assuming that the average length of a book is 250 pages, it would be possible to store information equivalent to 100 books on one disc-a small library. With a computer it is possible to search through this stored data for specific information. It will revolutionize the methods that we now use to obtain information and expand our capacities for applying information to the world around us.

Introduction of New Technologies. New materials for building computers are in development, which will expand the boundries of computer processing beyond what we are now able to imagine. Pask and Curran (1982) describe the development of semiconductors using biological materials, such as protein-lipid membranes. The October 31, 1983 issue of ComputerWorld, states that the goal of these "bio-chip" researchers is to produce functional microcircuits that are as much as 500 times smaller than current silicon based chips. The House Armed Services Committee has recommended that $10 million in 1984 defense

appropriations be devoted to research of this nature. Fibre optics and other technologies, in their infant stage, may play major roles in the development of computers in the future and quite possibly will stimulate faster development of the processing capability of computers.

Extension of the Computer. Hardware, that gives computers capability to interact with their environment and humans, will be improved significantly. This includes voice recognition, computerized speech, visual pattern recognition, appendages (hydraulic arms and legs) and tactile recognition. These developments make it possible to create more sophisticated robots and computers, which are easier for humans to use. The Nippon Telegraph and Telephone Corporation has already created a robot, which can read the news with 99.5% accuracy (Shane, 1983). More importantly, by searching the dictionary in its memory banks, the robot can deliver a properly inflected sentence by scanning a printed page. Restrictions that now limit the applications of computers and robots will diminish by 1998 as their ability to control and interact with their environment continues to expand.

Computer Networks. Networks that allow the exchange of information between computers will continue to grow. The Source, CompuServe and Dow-Jones New Retrieval have been the dominate sources available to the average consumer. Fortune magazine (November 14, 1983) reports a new effort by Knight-Ridder to introduce Viewtron, uses a specialized terminal that converts a television set and telephone line into a computerized communications system. This system will contain national news, local news, Grolier encyclopedia, Scott Foresman reading series, a SAT cram course, Official Airline Guide, road maps, nautical maps, all

for only $12 a month and $1 in telephone charges for each hour of use. In addition, Viewtron users can do electronic banking (12 local banks), pay bills, and shop with over 100 south Florida retailers. All of this can be done in color with visual images, which is a significant advance over similar services. Fortune goes on to describe the potential growth of this type of service. It is inevitable that the application of computers, television, and telephone lines will increase the amount of information and services available to a person in their home.

Intelligent Computers. Computers will become intelligent by 1998, if they are not already. Robert Jastrow (1981), a well known physicist, not only foresees computers as intelligent but considers them to be "an emergent form of life, competitive with man". When does he see a computer that can compete with man? In 1995, Edward Feigenbaum and Pamela McCorduck (1983) report on the concerted effort of the Japanese to develop intelligent computers called Knowledge Information Processing Systems (KIPS). The Japanese goal is to introduce KIPS in the early 1990's. These computers will certainly possess intelligence. There remain questions about such intelligence. How much is it like human intelligence? Will the intelligence of computers make them "smarter" than humans? Regardless of how these questions are answered, we will soon be able to answer them out of experience and not speculation.

THE IMPACT OF COMPUTERS ON SOCIETY

Computers have brought about profound societal changes and will continue to do so. These changes are described and their implications examined in the following pages.

Information. The Honeywell Corporation estimates that knowledge doubled from the period of Christ's birth to 1750 but it is now doubling every 5 years. John Naisbitt (1982) has clearly articulated the evolution from an Industrial to Information society that has occurred in the last 30 years. Computers make it possible for man to develop, store, organize, analyze, and apply this knowledge with speed unattainable by humans. For example, it would take a human being a lifetime to complete the same number of calculations that a supercomputer can execute in one second.

The availability of information is increasing. If we believe that information is power, then we can expect one of two things to occur. The diffusion of power throughout society will continue, rather than being concentrated in the hands of an elite few. The proliferation of microcomputers and large public data bases are examples of this trend. A second possibility is that public information may be manipulated or a type of "disinformation" may take place.

Public access to computerized data bases is increasing and undoubtedly will continue to expand. There are dozens of commercial data bases available to individuals who own personal computers. Dialog subscriptions, which have long been available to larger businesses, are not available to individuals. Plato, a major collection of computer assisted instruction programs, can now be accessed by IBM Personal Computer owners. Reference has been made to other data bases and services, such as Viewtron, that will be developed at the local level. However, this diffusion is only the tip of the iceberg.

People are using the computer to share information with other people all over the country through electronic bulletin boards. These

bulletin boards are run by individuals, businesses, and computer user groups as a means of disseminating information to personal computer users. Hundreds of these bulletin boards exist and are accessible free of charge. Electronic bulletin boards become an information base that grows and expands as more people share and become a part of it. Obviously, it is extremely difficult to control information dissemination that is so dynamic. Never before has there been such freedom of speech available. You are not subject to having the government or news media control what you say or what you hear.

Frude (1983) cautions that centralized data banks portend the possible manipulation and control of information be those who own the data banks. We will only be able to access information that they want us to find. For example the works of a politically unpopular author could be wiped out of the data banks with one command.

Pask and Gordon (1983) caution that our access to information can be monitored by the government or businesses. Thus threatening our privacy. It will be technically feasible to monitor what information is obtained and supplied to determine our political and buying preferences.

Work and Leisure. Robots are now being installed in factories in lieu of rehiring layed off workers. There are optomistic projections about this phenomena, claiming that is simply a displacement of workers, and retraining will result in new employment opportunities for those displaced. The Secretary of Labor, Ray Donovan (1983) reports that the Robot Institute of America predicts that 440,000 jobs now done by humans will be eliminated by robots before 1990; however, after company

retraining only 22,000 people may lose their jobs. Many industrial experts cite the benefits of these robots as they replace hazardous and boring jobs.

There are other experts who are not so optimistic. Harvey Shaiken, an MIT researcher who studies the impact of technology, says "The competitive rationale may be true, but it doesn't say anything about the 25% of the workforce that is going to be displaced, and find themselves in a drunken stupor...unless this issue is grappled with, the U.S. will set the stage for a very explosive set of circumstances." ComputerWorld (October 10, 1983) reports that Japanese unions are beginning to recognize the threat to jobs that robots pose in their country and are now formalizing the lifetime employment agreements that up to this point in time have been informal commitments to workers by business and industry.

Production workers are not the only ones who will be affected by computers and robots. Daniel Goleman (February, 1983) reports that there are now 1 million computers and 4 million terminals in place in the U.S. This number is expected to increase 25% each year for the next decade. The impact of office automation is likely to be highly significant. Shea (September 27, 1982) states that some computerists expect that there will be a restructuring or elimination of secretarial jobs, when managers realize that it is more efficient to enter data and manipulate it themselves.

ComputerWorld (October 31, 1983) reports that Phillip Kraft, has conducted a survey showing that the ranks of middle managers is thinning. He suggests that organizational charts of the future will

look like hourglasses with a concentration of high level executives, few managers, and a large number of office workers at the bottom. This is reinforced by a Wall Street Journal article (January 12, 1983) that describes chief executives who bypass their managers to directly access the information they want through terminals.

Clearly, computers and robots are redefining the workplace. Workers will need to undergo retraining more frequently. Most workers who are now affected by the installation of robots and computers are blue collar, but as we create more intelligent computers, white collar workers will also be affected. The possibility looms that by the end of this century, few people will be needed to perform the tasks necessary for either production or management.

Workers will not only find their jobs changed, but are likely to experience a reduction in their work time and workplace. The potential result of job displacement will be a negotiation of shorter work weeks according to Edward Blakely (ComputerWorld, September 5, 1983). Gradually leisure will occupy a large majority of a person's time. Pask and Curran picture a society in which the individual can devote most of their time to sports, aesthetics, and learning. In a society where individuals have difficulty adjusting to retirement, it will be no small accomplishment for this shift to a leisure society to take place.

Human Interaction. Computers and telecommunication advances portend the reduction of necessary human interaction. Business transactions will increasingly occur through electronic subscription services. Many experts predict a shift of work from the office and plant to the home. Educational activities can be supervised at home by teachers monitoring

the work of a student via computers and telephone linkages. Individuals will find a decreasing level of human interaction necessary to survive. Education, work, leisure, shopping, and other life necessities can be taken care of at home. This could result in a withdrawal of many people from society.

Computers provide for many psychological needs, many which cannot be obtained by those who are socially unskilled. Evidence of the effect that computers can have on social interaction can be seen in the isolation of teenagers with their video games and computers, and by adults who subject their spouses to the status of computer widows or widowers.

There are indications that computers as mediaries between humans affect relationships. Goleman (1983) describes the differences that can be observed in the communication that takes place between individuals during a computer conference compared with face-to-face encounters. A comment such as, "Do not be an idiot. You are a complete and total ignoramus.", often appear in computer conference proceedings. This is termed "flaming". There appears to be less restraint and concern for another person's feelings when a message is communicated by computer.

Another example of the affects that computers have on human relationships is related by Van Gelder (1983). She describes the CompuServe "CB" simulation, where computer users can communication with each other in freeform style. Communicating through "CB", users attempt to communicate body language and reactions, as well as, verbal responses. Gelder describes adults caught up in fantasy that they would probably not engage in during a face-to-face meeting. This is most

profoundly exhibited by Compusex, the attempt to simulate sexual relationships via the computer. One incidence cited an occasion, where a couple engaged in computer sex, terminated the conversation by computer to talk by phone. When they made the transition, the "walls went back up".

Frude (1983) observes that we will eventually develop the "intimate machine". The intimate machine would be designed to cater to all of our human needs. He pictures it as more capable of supplying our social, psychological, and physical needs than other humans, because it would be programmed to know exactly what those needs were and how to satisfy them.

Computers and robots also provide the tools needed by the handicapped. InfoWorld (December 14, 1981) describes the jobs that handicapped persons can perform, such as word processing and computer programming. An article in Time (December 13, 1982) reports on the uses of computers to circumvent handicaps. The development of voice synthesis and recognition and other peripheral devices will further make the computer an indispensable companion to the handicapped. Computers will very likely become a companion enriching and easing the lives of handicapped persons. Frude (1983) also proposes that computers become companions to the elderly that increasing their independent years.

As computers and robots develop intelligence and expand their communication and material handling abilities, we will probably see a more involved and richer degree of human interaction with the computer. What will be the ultimate affects of this human-computer interaction? This appears to be an area where monumental and unforseen consequences will take place.

Ethical and Social Issues. There are a number of social and ethical problems that are raised by computers and robots going beyond those issues we have already examined. We present a quick synopsis of a few issues which seem most important.

As computers reduce the necessity of human involvement in work, it will be necessary to consider the distribution of wealth created by computers and robots. Already we are sensing a developing rift between the poor and wealthy as they are introduced to the benefits of computers. InfoWorld (October 31, 1983) reports that 70% of wealthy schools have computers while only 40% of poor schools have them.

There is a danger that we will create a society characterized by not only material differences but a group of knowledge "haves" and "have nots". Time (November 11, 1982) puts it quite succinctly, "Will the rich get smarter while the poor play video games?" There is a disturbing trend which indicates the answer to Time's question is "yes".

This potential effect is countered by the efforts of several people hoping to overcome the problem. Some experts contend that computers, particularly personal computers, are an impetus in bringing informational power to the masses. Fred Moore, one of the founders of the Homebrew Computer Club (one of the most famous computer user groups in the U.S.) started the club with the hope that personal computers, built by individuals would be an alternative to large industry and give computing power to the people by favoring applications over profits. The Homebrew Club ended up spawning several Silicon Valley industries, including Apple Computer. Moore now laments the concern for commercial gain among club members.

Another attempt to bring computer literacy to the masses is described by Liza Loop (September, 1982) in the ComputerTown U.S.A. project. ComputerTown is "a grassroots attempt to make this modern rite of passage (learning about computer technology) easy, exciting and available to everyone." With assistance from the National Science Foundation, it is possible that ComputerTown can succeed in its goal to establish ComputerTown projects across the country.

Computers and robots will also force us to examine important ethical issues over the next fifteen years. The most important is to the re-examination of our definition of life. Jastrow (1981) suggests that computers are the next evolutionary step and that we as humans should graciously allow them to ascend the ladder above mankind. Frude (1982) echoes this sentiment and proposes that we must learn to overcome our biological chauvinism and grant computers the same rights that we as humans possess.

The question of what constitutes life and whether intelligent computers and robots are a lifeform will become increasingly important. Perhaps the question will be answered for us. Marvin Minsky, a premier researcher in artificial intelligence, says a machine will come into existance with the "general intelligence of an average human being...the machine will begin to educate itself...in a few months it will be at a genius level...a few months after that its power will be incalculable...If we're lucky, they might decide to keep us as pets."

Learning. Computers are a catalyst in the understanding of the human mind, intelligence, and learning. The research in artificial intelligence is contributing to our knowledge about how we think and

learn. Moreover, computers offer a technology to immediately improve learning through computer assisted instruction, simulation activities, telelearning, and information services. The impact of computers on education, particularly adult education, will be more thoroughly explored in the next section of this paper.

IMPACT ON ADULT EDUCATION

Computers will also affect the way that we educate people. The implications for the future of education should be encouraging to many adult educators. The computer may have a more positive impact than would be possible through the efforts of educational reformers. There will be three major changes resulting from the computer's influence.

When Learning Takes Place. There will be an increasing emphasis on lifetime learning. The expansion of knowledge, rapidly changing structure of work and subsequent increase in leisure time will all contribute to a trend in lifelong learning.

Naisbett (1982) identifies ten megatrends occurring in our society. One of these is the shift from short-term to long-term solutions. He sees a shift to lifelong learning and retraining. Specialists will find their skills quickly become obsolete, while the generalist committed to lifelong education can change with the times.

Technological development will result in the displacement of a significant majority of the workforce. Moreover, displacement is likely to occur with increasing frequency. Donovan (1983) cites a study completed by the Carnegie Mellon University which concludes that by roughly 1999, non-servo robots (the simple type) will replace 1 million workers, while servo robots will replace 3 million workers. He further

states, that by 1990, 40% of college students will be over 25 years old, many of whom are preparing for new careers. There will be a dramatic retraining of the workforce, both blue collar and white collar. However, it is not just a one time event, but is a lifetime activity.

Pask and Curran describe a society where leisure activities are predominate. They suggest that individuals will begin to pursue education and learning as a leisure activity. It is possible computers and robots will support society and supply human needs without human labor. When this happens, many people will be motivated to seek knowledge and learn new skills that they do not have time to pursue as society is presently organized. Lifelong learning may be destined to become a primary activity that prevents mankind from becoming bored and apathetic.

Adult educators should welcome this trend. It is encouraging to see popular writers like Naisbett stress lifelong learning. The term is no longer unique to the vocabulary of adult educators, but has become familiar to a broad base of the entire population.

Where Learning Takes Place. Perhaps the most dramatic change that we will see in education during the next 15 years, is where it takes place. Zamora (May 3, 1982) says that "the artificial distinction between learning, working, and recreating will begin to blur as schools, offices, and entertainment locations become processes instead of places". Computers offer a technology that makes it possible to learn anywhere.

When you combine the learning potential of the computer with television, interactive videodiscs, telephones, and join them into a unified system through CATV, telephone networks, and communication

satelites, you have a medium for more effective learning than any ever imagined. The world becomes our learning resource. Experts from around the world will electronically visit our homes. The world's libraries will be at our fingertips. With a few minutes notice, discussions on a subject can be arranged with people around the globe. You can contribute your own knowledge and opinions to data banks to be shared with people in both present and future generations.

TeleLearning has recently announced "The world's first electronic university". This system provides personal computer owners an opportunity to enroll in a wide variety of subjects. TeleLearning supplies a computer diskette that enables a personal computer with a modem to establish a communication link with the learning network. The student can them communicate with an instructor who "will guide, motivate, test and help each student". There are limitations to the system, but it illustrates what can be expected in the future.

Learning will occur anytime and anywhere in the near future. It is quite possible that by 1988 we will be able to take a computer anywhere we go. The portable computer technology available today makes it quite feasible to expect a handheld computer with the power we now have in our best desktop computers. When this type of computer is combined into a single unit with a radio phone (these phone systems are now being installed and will be available in most metropolitan areas by 1990), it will be possible to use the handheld computer to access your home computer, a friend's computer, or any major data bank in the world, from anyplace and at anytime. Frank Herbet (1980) suggests in the distant future that a computer will be implanted in the brain which can

communicate with outside computernetworks. How much will conversations and discussions be enriched when the participants can access a global body of information? Our access to knowledge will become voluminous and instantaneous. This will definitely cause us to think of our entire environment as a learning place. Our society will truly become a learning society.

How Learning Takes Place. Methods for teaching adults will be altered as the computer continues to exert changes within our society. Learning will become more process oriented and less rote memorization of facts and skills.

Knowledge oriented teaching will diminish as it becomes apparent that individuals cannot efficiently store the quantity of information needed to be expert in a given field. Rather, methods will be taught to extract, analyze, synthesize, and apply knowledge. What is the point of memorizing large bodies of fact when we can instantaneously access data banks of knowledge immensely larger than a human brain is capable of adequately storing? In other words, we will have to teach people how to learn and apply what they have learned, not teach them simple facts.

Learning networks will make learning a more dynamic process than has ever been possible. Books can be written by thousands of people as they each contribute their own thoughts to an electronic book. Publishing will occur immediately, rather than the usual year long process, which makes a great deal of written material outdated before it is published. Information from hundreds of books can be scanned and selected topics extracted in a few minutes. Data can be shared with hundreds or thousands of people who are a part of our learning network.

There will no longer be restraints on the dissemination of knowledge that results from books, journal and magazine articles funneling through "experts" who determine what will be published.

Computer assisted instruction will be available on thousands of subjects. In the past few months, dozens of high quality CAI programs have been introduced to teach management skills. This software development will grow as CAI authoring systems become more powerful. Authoring systems will provide the tools that non-programmers need to design CAI instructional materials. Simulation programs will allow a person to develop skills through experience that is close to "real life".

CHANGES FOR THE ADULT EDUCATOR

The profession of adult education will change. There are six significant changes that must take place if adult educators are to find a role in the learning process of the future.

1. Adult educators must become technologically proficient. The proficiency must be in the area of applying technology to learning. Education is playing catch up at this point. Too many educators are concentrating on the computer as an end and not a means to improve education. Computer literacy workshops for educators abound; however, they emphasize the computer-how it works, what it does, and how to program it. Adult educators must concentrate on how the computer can improve the learning process-how to apply it and not just how to use it.

2. Adult educators must become learning designers. It is necessary that we design learning activities that take advantage of new technology. Computer based learning networks will be one design area. Computer assisted instruction is another. Designing learning programs

that improve human and computer-robot interaction will become increasingly critical as the need for effective human and computer communication increases. Perhaps the most important area of learning design will be the creation of learning environments which encourage the improvement in human relationships.

3. Adult educators must become learning facilitators. They will counsel adults about strategies that can be used to learn new skills or access unfamiliar information. This must include the ability to identify when the computer or human interaction is the best strategy for learning. The potential for individualized learning becomes a reality with computers, robots, and learning networks.

4. Adult educators must become futurists. The changes that have been described in this paper are but a tip of the iceberg. It is amusing to look back on predictions that are only two or three years old and realize how far afield they were. For example, the January, 1983 issue of Byte contains an article that forecasts a total of 10 million personal computers would be installed in business, education and home somewhere between 1985-86. However, there were that many personal computers installed by the end of 1983. While it may seem impossible to predict what the future may bring, it is possible to identify trends and anticipate what we must do to adjust to these trends.

5. Adult educators must become social reformers. Computers and robots represent tools that may be applied in benevolent or malevolent ways. They can improve the social well being of all citizens or permanently install a powerful elite. It is necessary that adult educators concentrate their efforts in ensuring that computers and

robots are used to further the democratic ideals upon which the United States was founded. The Chautauqua movement (Stubblefield, 1981) serves as a model for social reform through learning that we can use for inspiration and ideas.

6. Adult educators must become social philosophers. The ethical and moral issues that must be faced as computers and robots become an integral part of society are enormous in their importance. Educated choices must be made by people and should not be based on emotional reactions. Adult educators can assist in this process if they become familiar with philisophical methods and discussions that are related to the ethical and moral problems, which have their genesis in computer and robots.

Adult educators must be aware of the impact that computers are having on our society and provide the resources and leadership necessary to help adults learn to adjust to these changes and face life's challenges. Whether you concur with the realism of the issues raised by this paper, or feel that all relevent issues have been clearly articulated, there is compelling evidence that computers and robots will change our world. Adult educators should be prepared for and not react to this transition.

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